Risk factors associated with the incidence of foal mortality in an extensively managed mare herd

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Abstract

The purpose of this study was to determine the incidence of neonatal mortality in a large, extensively managed mare herd and what risk factors were involved in foal mortality. For a 6 wk period between April 18, 1994, and May 31, 1994, 334 foals were born, of which 74 died before reaching 10 d of age, giving an overall mortality of 22% for this period. Seventy four percent of the foal deaths occurred within 48 h of parturition. The major causes of foal mortality included starvation/exposure 27%, septicemia 26%, and dystocia 20%. Weekly incidences varied significantly, ranging from 67% for week 1 to 14% for week 5 ($P < 0.01$). Other risk factors that were associated with foal death included failure of passive transfer ($P < 0.0001$), poor mothering ability ($P < 0.0001$), the presence of dystocia ($P < 0.0001$), low birth weight ($P < 0.05$), lack of rainfall ($P < 0.01$), and low temperatures ($P < 0.1$). The effect of sire, mare age, mare body condition, and foal sex were not significant risk factors for foal survival ($P > 0.1$). Further studies are required to determine if changing management procedures will be effective in reducing the incidence of neonatal foal mortality in this extensively managed herd.

Résumé

Les facteurs de risque reliés à la mortalité des poulains dans un troupeau de juments hautement régi

Cette étude avait pour objectif de déterminer l'incidence et les facteurs de risque associés à la mortalité néonatale dans un grande troupeau de juments régi de façon rigoureuse. La période d'observation s'est déroulée entre le 18 avril et le 31 mai 1994. Des trois cent trente-quatre naissances relevées durant ce temps, 74 poulains sont morts avant l'âge de 10 jours. Le taux de motalité s'est donc élevé à 22 %. Soixante-quatorze pour cent des mortalités sont survenues durant les premières 48 heures post-partum. Les principales causes de mortalité étaient les suivantes : inanition/exposition aux intempéries 27 %, septicémie 26 % et dystocie 20 %. L'incidence hebdomadaire a varié de façon significative ($P <$ 0,01) de 67 % la première semaine à 14 % la cinquième semaine. Les auteurs ont aussi identifié d'autres facteurs de risque de mortalité tels qu'un manque de transfert passif ($P <$ 0,0001), un pauvre instinct maternel ($P <$ 0,0001), la présence de dystocie ($P <$ 0,0001), un faible poids à la naissance ($P <$ 0,05), un faible taux de précipitation ($P <$ 0,01) et une basse température ($P <$ 0,1). Toutefois, le choix de l'étalon, l'âge et la condition physique de la jument et le sexe du poulain n'avaient pas d'influence ($P <$ 0,1) sur la survie des poulains. Les auteurs concluent que d'autres études sont requises pour déterminer si une modification des procédures de régie réduirait l'incidence de mortalité dans ce troupeau.

(Traduit par docteure Thérèse Lanthier)

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Introduction

Maintaining large numbers of horses under extensive management conditions is common in western Canada. Individual herd size varies from 50 to over 500 mares. Draft and draft-cross mares are most commonly used, although light horse breeds are also involved. In the past 5 y, the economic importance of foal mortality has increased markedly with a rise in foal value. Sale prices for weanling 3- to 5-month-old draft type foals were in the range of $350 to $450 in 1994.

The purpose of this study was to determine the incidence of foal mortality and to identify risk factors for foal mortality in one extensively managed herd. The variables examined included sire, mare age, mare body condition, mare's interest in the foal, presence of dystocia, foal birth date, foal sex, foal weight, foal immune status, environmental temperature, and precipitation. Lastly, the cause of death was determined for each case of foal mortality by gross necropsy examination.

Materials and methods

Mare management

The herd that was utilized in this study was located in western Manitoba and consisted of 415 pregnant

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Table 1. Foaling distribution and rate of foal mortality by week

Week	Number of foals born (%)	Weekly mortality (%)
1	9 (3)	6 (67)
2	31 (9)	14 (45)
3	78 (23)	17 (22)
4	93 (29)	18 (19)
5	79 (23)	11 (14)
6	44 (13)	8 (18)
Total	334	74

Belgian-cross mares. The mares ranged in age from 3 to 21 y. Exact ages were available for 297 of the foaling mares ($\bar{x}$ = 8.6 y, s = 3.6 y). The mares were pasture bred during a 75-day breeding season (June 1, to August 15, 1993) and, therefore, were 246 to 322 d of gestation on April 18, 1994, at the beginning of this 6-week study. The mares were kept in 4 large grass paddocks, ranging from 10 to 30 ha, with groupings based on age, such that paddock 1 contained 85, 3-year-old mares, and paddock 2 contained 77, 4-year-old mares; the remaining 253 older mares were split between paddocks 3 and 4. These paddocks contained no shelter, other than a small number of trees. Areas bedded with straw were present in each paddock, and water was provided by dugouts or natural ponds. Feed included native grass and alfalfa hays, which were fed in large round bales on a free-choice basis.

The mares were observed at 0700, 1300, and 1900 h daily. Mares and foals were moved from their original foaling paddocks to new paddocks (5 to 10 ha) 12 to 48 h after parturition (the time depended on how many other foals were born in that paddock). Twenty mares and foals were grouped in each of these paddocks. In cases where mares showed little interest in their foals or other mares were attempting to steal a foal from its dam, the mare and foal were placed in a small pen approximately 10 × 10 m for 6 to 12 h, before they were moved to a new paddock. Assistance to foals was minimal; it involved helping them to stand and ensuring that they were with their dam during each observation period. The study ended on May 31 when mares and foals were moved to summer pastures.

Treatment of mares and foals during the study involved normal farm practices. Any mares that were noted to have dystocia were assisted, using mutation, extraction, and fetotomy as required; these mares received 1 treatment of penicillin G (22,000 IU/kg bodyweight (BW)) and 40 IU of oxytocin (rogar/STB, Pointe Claire, Quebec), IM, after delivery.

Data collection

The following parameters were noted for each foal at the 1st observation period after parturition: date of birth; mare number; mare body condition score; mare's interest in the foal; foal gender; heartgirth, and distance from point of shoulder to point of hip; ambient temperature; and weather conditions, such as, rain, snow, or no precipitation. Each foal was identified by a numbered tag glued onto the right shoulder. Mare body condition score was determined by visual appraisal of the fat cover over the ribs, neck, back, and rump, and was

Table 2. Age of foals that died within the first 10 days of life

Age (d)	Number of foals	Percent of total deaths
0	29	39
1	25	34
2	13	18
3	5	7
4–10	2	3

Table 3. Causes of foal mortality in the first 10 days after parturition

Cause	Number of foals	% of total deaths
Starvation/exposure	20	27
Septicemia	19	26
Dystocia/asphyxia	15	20
Drowning	2	3
Killed by dogs	2	3
Nonviable twins	2	3
Acute abdomen[a]	3	4
Suffocation by placenta	5	7
Haemorrhage from umbilicus	2	3
Other	4	4

[a]Acute abdomens included mesenteric torsions (2) and hepatic rupture (1)

recorded on a scale of 1 (extremely emaciated) to 9 (extremely fat) (1). Mare interest was recorded as 1, little or no interest in the foal; 2, interested in foal and mildly protective; and 3, aggressively protective of foal. Environmental temperatures were grouped into the following categories: lower than −10°C, −10°C to 0°C, 1°C to 10°C, and higher than 10°C. Foal birth dates were grouped by week. Foal weight was estimated using the equation: weight (kg) = [heartgirth (cm)]^2 × distance from point of shoulder to point of hip (cm)/8700, which was a modification of the original equation developed by Milner and Hewitt (2). Using the mare's number, the mare's age and the sire were determined from existing farm records.

For each live foal a 5 mL blood sample was taken from the jugular vein, 12 to 24 h after parturition, for measurement of immunoglobulin status using a Cite foal immunoglobulin G test kit (Agritech Systems, Portland, Maine, USA). This semi-quantitative system measured immunoglobulin G (Ig G) levels as <2.00, 2.00 to 4.00, 4.00 to 8.00, or >8.00 g/L. Foals with less than 4.00 g/L of Ig G were classified as having failure of passive transfer (FPT) (3–5). Immunoglobulin status was not determined for foals that died before 12 h of age, or in those cases where extremely aggressive mare behavior precluded handling of the foal.

Necropsy

Where foals died or were dead at birth, they were removed for necropsy and their dams were moved to a 30 ha pasture that contained other open mares. Dead foals were necropsied within 12 h of their death. This involved a complete gross examination of each foal and examination of the placenta in the case of foals found dead

Table 4. Odds ratios for variables that were associated with the rate of foal mortality

Variable	n	Odds ratio	Significance
Foaling difficulty			
normal birth	319	1	
dystocia	15	17	$P < 0.001$
Mare interest			
1	17	25	$P < 0.05$
2	179	1	
3	138	0.5	$P < 0.05$
Foal weight			
20 to 40 kg	15	5	$P < 0.05$
40 to 50 kg	164	1.4	$P > 0.05$
50 to 70 kg	155	1	
Foal immune status			
<4.00 g/L Ig G	45	63	$P < 0.001$
>4.00 g/L Ig G	289	1	
Week of birth			
week 1 and 2	40	4	$P < 0.01$
week 3 to 6	294	1	
Environmental temperature			
−10°C to 0°C	84	1	
0°C to 10°C	240	0.8	$P > 0.1$
>10°C	10	0.3	$P < 0.06$
Precipitation			
no rain	307	1	
rain	27	0.1	$P < 0.01$

within 12 h of birth. The cause of death was determined, but in infectious cases, an exact etiological diagnosis was not made.

Statistical analysis

The association between the incidence of foal mortality and each of the following factors: sire, mare age, mare body condition, mare's interest in foal, foal sex, foal weight, foal immune status, foal birth date, environmental temperature, and precipitation were tested using the chi-square test of independence, or Fisher's exact test if the expected frequency of any cell was below 5 (6). Analysis of sire effect was performed after sorting the data based on mare age, as individual stallions were bred to particular age groups of mares, specifically, 3-year-olds, 4-year-olds, and 5-year-olds or older. Comparisons were made within variables with greater than 2 values by subdividing their frequency tables and determining odds ratios. These calculations were performed using SAS (SAS Institute, Cary, North Carolina, USA). Confounding between variables was corrected using the Mantel Haenszel chi-square test (6).

A mathematical model for determining the probability of foal mortality was developed using logistic regression and the BMDP software package (BMDP Statistical Software, Los Angeles, California, USA). Variables with $P < 0.1$ using chi-square analysis or Fisher's exact test were used in a complete model to determine their significance. The final model was developed using a stepwise procedure that removed variables with $P > 0.05$.

Results

Three hundred and thirty-four of the 415 mares that were observed during the 6-week period foaled. These included 62 3-year-old mares, 55 4-year-old mares, and 214 mares between 5- and 21-years-old. The mares varied in body condition scores from 3 to 6 ($\bar{x} = 5.2$, $s = 0.6$). Environmental temperatures at the time of initial foal observation ranged from −8°C to 22°C ($\bar{x} =$ 5.9°C, $s = 6.4$). No snow was observed during the study period; 27 foals were first observed during rain. Estimated foal birth weights ranged from 22 to 69 kg ($\bar{x} = 50.3$ kg, $s = 5.8$).

The weekly distribution of foal births and deaths can be found in Table 1. The overall incidence of foal mortality in the 1st 10 d after parturition was 22% ($n = 74$), with 73% of these deaths ($n = 54$) occurring within 48 h of parturition (Table 2). Necropsy results indicated that the most common reasons for foal mortality were starvation and/or exposure (27%), septicemia (26%), and dystocia (20%) (Table 3).

Fifteen cases of dystocia were noted; 11 foals were dead at parturition, while only 3 of the remainder survived. Mare interest varied significantly among mare age groups ($P < 0.05$), with 3- and 4-year-old mares being twice as likely to show little interest in their foals as mares 5 y and older; these older mares were also 8 times more likely to be aggressively protective of their foals than were young mares. Although 3-year-old mares had a higher incidence of foal mortality than did mares 5- to 9-years-old, this effect was not significant ($P > 0.1$) after mare interest level was controlled.

Immunoglobulin levels were determined for 274 of the 334 foals born. Of these, 45 foals had failure of passive transfer (<4.00 g/L Ig G), and 32 of them died.

The variables sire, mare age, mare body condition, and foal sex were not significantly associated with the rate of foal mortality ($P > 0.1$). Odds ratios for each of the variables that were found to be significantly ($P < 0.1$) associated with foal mortality (difficulty in foaling, mare interest level, foal weight, foal immune status,

Table 5. Proportion of foals that died given particular levels of mare interest in the foal and foal immunoglobulin G levels

Foal Ig G level	Mare interest level[a]		
	1	2	3
0–4.00 g/L	1.0	0.74	0.55
>4.00 g/L	0.33	0.03	0.05

[a]Mare interest: 1 = no interest in foal or signs of protecting foal, 2 = mildly interested and protective of foal, 3 = aggressively protective of foal

week of birth, environmental temperature, and precipitation) are listed in Table 4.

The complete mathematical model containing week of birth, occurrence of dystocia, mare's interest in the foal, foal weight, foal immune status, temperature, and precipitation (variables with $P < 0.1$ using chi-square analysis) was highly significant in predicting foal survival ($P < 0.0001$), as compared with a model containing no variables. The final model, which was produced by removing variables with a P value of >0.05, contained only foal immune status and mare interest level. The

$$\text{Probability of foal death} = \frac{e^{4.1 - 4.2(\text{FIS}) - 2.9(\text{Mi2}) - 4.2(\text{Mi3})}}{1 + e^{4.1 - 4.2(\text{FIS}) - 2.9(\text{Mi2}) - 4.2(\text{Mi3})}}$$

with e = 2.71828. Foal immune status (FIS) was 1 if the measured Ig G content in the foal's serum 12 to 24 h after parturition was >4.00 g/L; it was 0 if the Ig G level was < = 4.00 g/L. Mare interest 2 (Mi2) equalled 1 only for mares that were mildly protective; mare interest 3 (Mi3) was 1 only if the dam was aggressively protective of her foal. Mi2 and Mi3 equalled zero for mares with no interest in their foals. The actual probabilities of foal death for each level of foal immune status and mare interest are listed in Table 5. The final model accounted for 77% of the total measured variation in foal mortality levels.

Discussion

The incidence of foal mortality (22%) associated with the management system used on this farm was high compared with other management systems. Horse herds maintained in France for meat production under similar management systems reported foal mortality from birth to weaning ranging from 13% to 20% (7,8). Management systems aimed at the production of riding horses had much lower mortality rates in foals up to weaning (3% to 12%), as riding horses were usually produced on much smaller farms and individual animals were assigned a higher value, so that more resources were spent on individual foals (9–15).

Dystocia accounted for 15 deaths and, as previously noted by Vandeplassche (5), was most frequently the result of malpresentations. We proposed increasing the number of observation periods, especially in the late evening and early morning when most mares foal (16), as a means of reducing the number of foals lost due to dystocia. How frequently observations would be needed was not determined, but it would probably be at least every 4 h.

Mare age was expected to be a risk factor for foal mortality, based on its reported effects on colostrum quality and quantity (5,17), foal size, and difficulty in foaling (5). Young primiparous mares were predicted to have poorer colostrum, smaller foals, and a higher occurrence of dystocia than older multiparous mares. Once the confounding effect of mare interest level was removed, however, mare age was not a significant risk factor for foal mortality ($P > 0.05$). The lack of a significant mare age effect was attributed to similar colostrum quality levels in all age groups, as noted by Morris *et al* (3) and Shideler *et al* (18), or the absence of a significant difference ($P > 0.05$) in the number of dystocias or small foals (<40 kg) between 3- and 4-year-old mares and mares 5-years-old and over in this population.

The dam's mothering instincts appeared responsible for keeping the mare and foal together in the first 24 h after parturition, such that foals born to dams with poor mothering ability were at a significantly higher risk of FPT ($P < 0.01$). Mothering problems in young mares were observed to include lack of any interest in their foal or confusion as to which foal belonged to them. Problems in older mares were the result of dominant periparturient mares stealing foals from their actual dam. In either case, we proposed a possible solution for the future that involved housing smaller numbers of mares together, thereby reducing the likelihood of several mares foaling simultaneously, and moving every mare and foal into a small corral for 12 to 24 h immediately after foaling.

The body condition scores for the mares that foaled ranged from 3 to 6. It is possible that mare body condition score is a significant risk factor for foal mortality, however, it did not appear significant in this study because of little variation. This relationship should be reexamined in a herd with greater variation in mare body condition.

The most important risk factor for foal mortality noted in this study was FPT (<4.00 g/L Ig G). In previously published reports, FPT resulted from failure of the foal to consume colostrum, an inadequate quantity or quality of colostrum, loss of colostrum before foaling, or failure to absorb an adequate amount of antibody from the gastrointestinal tract (5,6,19–21). Agalactia was not noted in any of the mares that foaled, while colostrum quality, consumption, and absorption were not directly measured. Failure of passive transfer in these foals was attributed to inadequate colostrum consumption, because 20 of the foal deaths were associated with starvation and exposure. In a previous study, the incidence of FPT was reportedly reduced by tube feeding colostrum within 12 h of parturition (19). We proposed that a management system be developed to identify foals that were at an increased risk of FPT, as treatment of all foals was impractical. Foals were observed to lose interest in suckling within 6 to 8 h after parturition, if they had not successfully suckled by that time. A system based on observing this change in foal behavior could be used to determine which foals to supplement with colostrum.

An increased number of foal deaths were seen in foals weighing less than 40 kg, but no increase was seen in very large foals. The small foals were observed as less active and, occasionally, even had difficulty in physically reaching the udder, so that death in most cases was associated with inadequate colostrum or milk consumption.

Environmental temperature was expected to be an important risk factor for foal mortality, as it has been reported to affect the incidence of FPT (17). If greater fluctuations in environmental temperature had occurred, with more foals being born at temperature extremes, a more significant effect of temperature might have been shown.

When examining the effect of wk of birth on foal mortality, the effect of temperature was removed, as temperatures tended to be higher at the end of the study. A possible reason for a temperature independent effect for week of birth was that all of the mares that foaled in the first 2 wk were less than 340 d of gestation. It was possible that foals born between 320 and 339 d of gestation were less mature and less able to survive than foals born after 340 or more d of gestation. Another possibility is that the decreasing density of mares in the foaling paddocks over the study period may have produced less mismothering and greater foal survival in the later portions of the study period.

Lack of rain remained a significant risk factor ($P < 0.05$) after removing the effects of week of birth, mare age, mare interest level, foal immune status, and temperature. This association was the opposite of what one would expect, and possibly represented a chance occurrence. A reexamination of this relationship was suggested for future studies.

The final logistic regression equation indicated that the most dramatic improvements in foal survival in the future could be achieved by procedures that affect the foal's immune status and the dam's interest level. For example, a foal born to a mare that was mildly protective but with failure of passive transfer as a result of consuming inadequate colostrum had a 74% probability of death. If foals identified at risk based on changes in their behavior were assisted to find the udder and or tube fed colostrum to raise their Ig G level to over 4.00 g/L, a marked reduction in the probability of their mortality could be expected. We suggested a permanent goal of reducing foal mortality to 10% or less.

How useful these findings will be for other extensively managed horse herds depends on how closely the animals and management procedures are similar to the operation utilized in this study. Further research in this area should examine whether particular changes in management, such as foaling out mares in smaller groups by subdividing paddocks, will be effective in reducing the incidence of foal mortality.

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CORRECTION

Immunosuppressive drug therapy

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Unfortunately, the name of the drug used in a key sentence in the above feature was published incorrectly. Under the heading *Cyclophosphamide,* the last sentence should read "Due to the serious adverse effects of cyclophosphamide, therapy is limited, if possible, to 4 to 6 wk.".